Integrated farm energy systems: Commercializing a better biorefinery

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Advances in technology, changes in the crop prices, rising fuel and transportation costs, and growing public concern over the environmental impact of current farming and feedlot practices, have set the stage for a remarkable opportunity to create an Integrated Farm Energy System (IFES).

The proposed IFES includes a locally managed system comprised of a 15 million gallon/year (GPY) ethanol plant that uses local crops and an adjoining 25,000 head confined cattle feedlot that is connected to an anaerobic digester. It will produce fuel-grade ethanol, finished cattle, biogas and biofertilizers. Because of proximities and integration of its components, the IFES is economically attractive with an estimated Internal Rate of Return (IRR) that exceeds 25%. This is achievable because of economies of scope. An IFES can reduce commodity transportation costs, reduce ethanol plant capital and operating costs because it is no longer necessary to dry the distillers grains, permit the co-utilization of facilities, equipment and personnel, and allow for the reuse of energy, water and nutrients throughout the system. It is possible to have the IFES achieve "zero discharge" status. This significantly decreases the harmful environmental impact of some of today's current production practices.

The primary outputs of an IFES include ethanol, CO2 recovered from the ethanol production process, beef, biogas power, and biochemical fertilizers. Deploying the IFES will benefit farmers and ranchers monetarily by creating new markets for their agricultural products. Because of its near "zero-discharge" process, the IFES can mitigate possible pollution problems as well as create new sources of employment in rural areas. This can help economic development in areas of the country that have least benefited from the recent economic boom, while simultaneously improving environmental quality.

The preliminary research outlined in this report has consistently revealed that the IFES is an advanced, highly beneficial, process to produce biofuels, biopower, quality beef and biofertilizers. Using the IFES process has the added value of: 1) Restoring soil organic matter to natural levels; 2) Improving the viability of family farms and ranches while strengthening rural communities 3) Enhancing the environment through less detrimental farming practices and reductions in greenhouse gas emissions; and, 4) Strengthening national and energy security.

IFES Components

The IFES is ideal for small rural communities. With a farm co-op style management system, it relies on local crops as the feedstocks for the fuel-ethanol plant. Corn by-products from ethanol production are used as enriched cattle feed in the form of wet distillers grains plus solubles (WDGS) that can replace more than 40% of the corn feed used today. The WDGS is used in the adjoining and enclosed cattle feedlot. The WDGS feed mixture will increase cattle growth rates, reduce the use of hormones and antibiotics in the feed ration while producing a higher quality beef. It also reduces the volume of CH4 emissions generated from cattle enteric fermentation. CH4 is 21 times more potent than CO2 as a greenhouse gas.

The final IFES component is an anaerobic digester located adjacent to the enclosed cattle feedlot. The digester replaces traditional animal waste storage tanks and lagoons, a major cause of pollution and feedlot odor. The digester takes a disposal problem and potential pollution source (manure) and converts it into biogas and slurry called digestate. The biogas contains approximately 60%-70% methane and is water saturated. The balance of the biogas mixture is CO_2, and some parts per million of hydrogen sulfide (H_2S).

Digestate contains a recoverable solid fiber with physical attributes similar to those of a moist peat moss, and will have a total solids concentration of 35%-40%. After separation in a processing facility, the fiber will be combined with appropriate admixtures and composted in windrows for 5-10 days until final maturation. After final maturation, the composted fiber product will be hauled off-site for use on the lands of participating farms as a soil improver.

After the fiber is removed, a liquid fraction called "filtrate" is created. A portion will be recycled as make-up water for the AD plant. Filtrate can be spread directly onto farmland for its nutrient value, and has combined nitrogen, potassium, and phosphate (N-P-K) percentages ranging from 3%-4.5% on a dry matter basis. The filtrate will be pumped into a special storage system sized to hold 12-months worth of liquid. The liquid can be shipped to participating farms for use as an organic nutrient.

If warranted, these biofertilizers can also be enriched with minerals and microorganisms and customized to enhance a region's depleted soil. Surface application of the biochemical fertilizer from the IFES also allows the use of low input farming practices, as opposed to the more energy intensive plowing practices. This significantly reduces fossil fuel use, and further augments carbon sequestration, helping to prevent soil erosion.

Conclusion

Work is underway to develop an innovative biorefinery that produces a combination of fuels (ethanol), power (methane), and chemicals (fertilizers). Each of the component technologies proposed for use is well proven on a "stand-alone" basis. However, none have been combined to fully capture their economies of scope through process integration. The first generation facility is based on producing 15 million gallons of ethanol per year, an adjoining feed yard holding 25,000 head of cattle with a closed manure collection system, and an anaerobic digester. The anaerobic digester will produce methane for use by the ethanol plant and biochemical fertilizers for use by farmers. The proposed process has the opportunity to substantially reduce capital costs and process inputs. Other benefits include a reduction in environmental pollutants such as biochemical oxygen demand (BOD), pathogens, nutrients, methane (CH_4), ammonia, and nitrous oxide (N_2O) emissions. Preliminary estimates indicate that 15.6% less corn will be required by the integrated system, which equivalently increases ethanol conversion efficiency from 2.60 gallons per bushel of corn to 3.08 gallons per bushel. Despite the efforts of the research community to develop energy crops, corn remains the least-cost source of sugars for ethanol production today. However, the proposed system allows the use of emerging ethanol production technologies that convert the hemicellulosic fraction of agricultural residues into five-carbon sugars that can be fermented and distilled when it makes economic sense. The proposed system will benefit farmers and ranchers monetarily, as well as mitigate possible pollution problems. Moreover, rural economic development will benefit from the implicit multiplier effect resulting from jobs created by implementing the proposed system. A commercial demonstration of this referenced IFES is undergoing final engineering and project development at a site located outside of Pierre, South Dakota. Construction is scheduled to commence early in 2002 and start-up is scheduled for early 2003.